Effects of Using 37°C Bupivacaine on Spinal Block Characteristics and Shivering

37°C Bupivakain Kullanımının Spinal Blok Karakteristiklerine ve Titremeye Olan Etkisi

Comprasion of 23°C Bupivacaine and 37°C Bupivacaine

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Özet

Amaç: Spinal anestezi uygulamasında kullanılan lokal anestezik ajanların sıcaklık ve dansitelerindeki değişim ile bu ilaçların beyin omurlik sıvısında yayılımları arasında ilişki olduğu gösterilmiştir. Spinal anestezi ile ilişkili olarak görülen titreme, hastaları oldukça rahatsız eden etiyolojisi tam olarak anlaşılamamış bir durumdur. Spinal anestezi amaçlı kullanılan 23 ºC'de oda sıcaklığında saklanan bupivakain ile 37 ºC'de saklanan bupivakainin spinal blok karakteristiklerine ve titremeye olan etkilerinin karşılaştırmayı amaçladık. Gereç ve Yöntem: Elektif sezaryen operasyonu geçirecek 80 hasta rastgele iki gruba ayrıldı. Grup 1 deki hastalara 23 ºC'de oda sıcaklığında saklanan 10 mg bupivakain; Grup 2 deki hastalara 37 ºC'de saklanan 10 mg bupivakain ile spinal anestezi uygulandı. Spinal anesteziden maksimum duyusal bloğun oluştuğu dermatom sahasına kadar geçen süre bunun yanında spinal anestezi sonrası ilk on dakikada her dakika daha sonra beş dakikada bir olmak üzere hastaların duyusal blok seviyesi, kan basıncı, vücut sıcaklığı, titreme insidansı kaydedildi. Bulgular: Her iki grup arasında demografik veriler arasında fark yoktu. Grup 2'de duyusal ve motor bloğun daha hızlı başladığını, sefalik yayılımının daha hızlı olduğu gözlendi. Titreme görülme insidansı sıcak bupivakainin grubunda daha düşük bulundu (p=0,022). Tartışma: Spinal anesteziyle gerçekleştirilen sezaryen operasyonlarında lokal anestezik ajanın sıcaklığının arttırılmasıyla "37 ºC" daha hızlı duyusal ve motor blok elde edilebileceliğini ve titreme insidansının düşürülebileceğini belirtmekteyiz.

Anahtar Kelimeler

Sıcak Bupivakain; Spinal Anestezi; Titreme

Abstract

Aim: Changes in the temperature and density of local anaesthesia agents used in the applicaton of spinal anaesthesia have been shown to be related to the dissemination of these drugs in the cerebral spinal fluid. Shivering seen related to spinal anaesthesia is extremely discomforting for the patient and the etiology is not fully understood. The aim of this study was to compare the effects on spinal block characteristics and shivering of bupivacaine stored at 23˚C or at 37˚C for use in spinal anaesthesia. Material and Method: A total of 80 patients who were to undergo elective caesarean section surgery were randomly separated into 2 groups. Spinal anaesthesia was applied to the patients in Group 1 using bupivacaine stored at room temperature of 23˚C and to the patients in Group 2 usng bupivacaine stored at 37˚C. A record was made of the time taken to reach the maximum sensory block in the dermatome field, the sensory block level at every minute in the first 10 minutes and at 5-minute intervals thereafter, blood pressure, body temperature, and the incidence of shivering. Results: No difference was determined between the groups in respect of demographic data. A more rapid onset of sensory and motor block and more rapid cephalic dissemination was observed in Group 2. The incidence of shivering was found to be lower in Group 2 with the warmer bupivacaine (p=0.022). Discussion: Raising the temperature to 37˚C in the local anaesthetic agent used in spinal anaesthesia of caesarean operations could achieve a more rapid sensory and motor block and could reduce the incidence of shivering.

Keywords

Warm Bupivacaine; Spinal Anaesthesia; Shivering

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Introduction

Several factors affect the dissemination within cerebral spinal fluid (CSF) of the local anaesthetic agents (LA) used in spinal anaesthesia. The density of the local anaesthetic used plays a significant role in the dissemination within the CSF and the level and duration of the effect of spinal anaesthesia [1]. The density of LA at a specific temperature value in ratio to the CSF density is known as the baricity. In the application of a local anaesthesia agent for spinal anaesthesia, the term of baricity is valid rather than the density of LA [2].

Besides several clinical studies which have shown that following the application of local anaesthetic in spinal anaesthesia, LA and CSF temperatures quickly equalise and there is no clinical effect of the temperature difference between CSF and the LA applied, there are also studies which have shown that a difference in LA temperature affects the onset of the block and the level of the block [3-5].

Shivering associated with spinal anaesthesia is an extremely frequently seen complication [6]. In addition to disrupting the comfort of the patient, shivering has various haemodynamic results, including increased oxygen consumption, increased carbon dioxide production and increased cardiac effort [7].

The aim of this study was to compare the effects of adifference in temperature of local anaesthetic applied intrathecally on the spinal block characteristics and shivering, in planned elective caesarean operations under spinal anaesthesia.

Material and Method

This double-blinded, randomisedstudy included 80 ASA I-II patients for whom elective caesarean section operation was planned at Kars State Hospital betweeen 08/06/2015 and 08/07/2015. Approval for the study was granted by the Local Ethics Committee and informed consent was obtained from all of the patients. Using the sealed envelope method, the patients were randomly separated into 2 groups of 40. Patients with any deformity in the vertebral column, neurological disease, allergy to local anaesthesia, infection in the planned injection area, drug allergy, or a diagnosis of pre-eclampsia were excluded from the study. On admittance to the operating theatre, ECG, non-invasive blood pressure, and SPO2 monitorisation were applied. Basal values were measured and recorded.

In case of a fall of >30% in the blood pressure or basal value systolic blood pressure falling below 90mmHg, it was planned to apply ephedrine 5-10mg iv, and if heart rate decreased below 50 min-1, 0.5mg atropine iv. Before the application of spinal anaesthesia, a peripheral venous vascular pathway was accessed with a 20 gauge branule and via this route, 10 ml/kg-1 saline solution infusion was administered. For standardisation, all intravenous fluids in both groups were heated to 37˚C and applied.

With the patient in a sitting position, the intrathecal space at L3-L4 level was entered with a 25 gauge Quinke type spinal needle. Spinal anaesthesia was applied by administering 2ml 10mg bupivacaine stored at 23˚C to the patients in Group 1 and with 2ml 10mg bupivacaine stored for at least 24 hours in a bain-marie (Memmert Waterbath WNB7, Germany) at 37˚C (regular temperature calibration was made) to the patients in Group 2. The solution to be administered intrathecally was prepared by an anaesthetist and given to a different anaesthetist who applied the spinal anaesthesia blinded to the temperature of the solution.

During the local anaesthetic injection, no aspiration or barbotage was made. Following the spinal anaesthesia, the patients in both groups were immediately placed in the supine postion. The pinprick test was used to evaluate the level of the sensory block and the Bromage scale was used to evaluate the motor block. The moment that the injection was made was defined as 0 min. The time was recorded for the maximum sensory block of the spinal anaesthesia to reach the dermatome area, then at each minute in the first 10 mins and at every 5 mins thereafter, the sensory block level, motor block findings, incidence of shivering, systolic arterial pressure (SAP), diastolic arterial pressure (DAP), heart rate (HR), oxygen saturation, amount of bleeding, and side effects were recorded.

When the sensory block reached T6 level, permssion was given to start the surgery. Throughout the operation, tympanic temperature of the right ear was measured every 20 mins. For standardisation, the temperature of the operating theatre was maintained at 23˚C. The APGAR score of the newborn was taken at 1, 5, and 10 mins. On postoperative Days 1 and 2, the patients were evaluted in respect of headache, backache and paresthesia, and the study was terminated.

In the statistical analysis of the study, a decrease of 50% in the anticipated incidence of shivering was taken as the basis to determine a sufficient number of patients as described in the study by Najafianaraki et al [8]. Using the Minitab program with α=5%, β=10%, the number of patients was defined as 80.

Statistical analysis of the data obtained in the study was made using SPSS for Windows 15.0 (SPSS Inc, Chicago, IL, USA) software. Conformity of the data to normal distribution was examined. Results were stated as mean and standard deviation, and median (minimum and maximum). Comparisons between the groups of the data obtained from the measurements were made using the Student's t-test and Mann Whitney U-test. In the comparison of numerical data, the Chi-square test and the Fisher Exact test were used. Data were stated as mean±standard deviation (SD), number (n), percentage (%), and median (minimum-maximum). A value of $p<0.05$ was accepted as statistically significant.

Results

No difference was observed between the groups in the evaluation in respect of age, weight, ASA, gestational week, and duration of surgery (Table 1).

In Group 2, the time to onset of sensory and motor block fol-

Table 1. Demographic Characteristics of the Patients (mean ±SD), n, median (min-max)

	Group 1 23 °C bupivacaine n:40	Group 2 37°C bupivacaine n:40	P value
Age (years)	25±4	24±4	0.789
Kilo (kg)	78±10	80±10	0.324
[a]ASA I/II	32/8	35/5	0.201
[b]Gestational week	38(36-39)	38(37-39)	0.658
Operating time (mins)	34±5	32±6	0.789

Student t test / [a]Chi-square test / [b]Mann Whitney U test

lowing spinal anaesthesia was found to be shorter. In Group 1, the time of the sensory block to reach the T6 dermatome was found to be longer. The time taken to reach maximum motor block and maximum sensory block was observed to be longer in Group 2. No difference was observed between the 2 groups in respect of the duration of the sensory block and motor block (Table 2).

Table 2. Evaluations of the sensory and motor block in the groups (mean ±SD), median(min-max)

	Group 1 23 °C bupivacaine n:40	Group 2 37°C bupivacaine n:40	P value
[a] Time to onset of sensory block (mins)	4.35±1.95	3.56±1.84	0.034*
Time to reach T6 dermatome (mins)	6(5-8)	5(3-7)	0.028*
Maximum sensory block level (T)	T2	T2	0.656
Time to reach maximum sensory block (mins)	9(6-10)	7(5-9)	0.048*
Duration of sensory block (mins)	125(115-145)	120(110-150)	0.156
Time of onset of motor block (mins)	7(5-9)	6(5-8)	0.041*
Time to reach maximum motor block (mins)	9(6-9)	8(6-10)	0.049*
Motor block duration (mins)	140(110-185)	135(120-180)	0.465

Mann Whitney U test / [a]Student t test

Shivering was observed less in the patients of Group 2, but the incidence of hypotension and bradycardia was greater. No difference was observed between the 2 groups in respect of the incidence of nausea, the blood loss during surgery and the APGAR scores of the newborns at 1, 5, and 10 mins (Table 3). On postoperative Days 1 and 2, no headache, backache, or paresthesia were observed in any patient.

Table 3. Shivering, haemodynamic changes, side-effects and APGAR scores of the groups, n (%), (mean ±SD), median(min-max)

		Group 1 23 °C bupivacaine n:40	Group 2 37°C bupivacaine n:40	P value
Shivering		8 (20%)	3 (7.5%)	0.022*
Hypotension		4 (10%)	8 (20%)	0.016*
Bradycardia		1 (2.5%)	4 (10%)	0.028*
Respiratory depression		0	0	0.895
[a]Blood loss (ml)		300±75	300±80	0.138
Nausea		3 (7.5%)	4 (10%)	0.751
[b]APGAR	1st min	8(7-10)	9(7-10)	0.147
	5th min	9(7-10)	9(7-10)	0.368
	10th min	9(7-10)	9(7-10)	0.567

Fisher Exact test, [a]Student t test, [b]Mann Whitney U test, *p<0.05

Discussion

The results of this study showed that when the local anaesthesia agent used for spinal anaesthesia was heated to 37˚C, a more rapid onset of sensory and motor block was observed, cephalic dissemination was more rapid, and the incidence of shivering was determined to be lower.

When the ionised and non-ionised fractions of the local anaesthetic are equal, the pH value is called the pKa value. The time of onset of the local anaesthetic effect is related to the pKa values. Medications in fluid solutions are found in both ionised and non-ionised forms. The ratio of both is related to the pH of the solution. The pKa of local anaesthetics is between 7.8 and 9.1 and the majority of medication in physiological pH (pH 7.4) is in ionised form. Changes in the temperature of local anaesthetic agents are known to have an effect on the pKa value. With an increase in temperature, the pKa value decreases and with an increase in the non-ionised fraction of the medication, it approaches physiological pH value. Therefore, because of this effect, bupivacaine solution at 37˚C has a more rapid onset of effect, increases the block quality, and extends the duration of the block [9, 10].

When thermodynamic principles are considered, with an increase in temperature, an increase in molecular kinetic energy and an increased number of mobile molecules are expected. It has been reported that accelerated distribution of local anaesthetic solution associated with increased temperature could create spinal block at higher levels [5, 11].

In a previous in vitro study, the density of 0.5% bupivacaine at 37˚C was measured as 0.9996 and was shown to have mild hypobaric features in comparison with CSF density at 37˚C [12].

Many in vitro studies have examined the effects of change in local anaesthetic temperature on density and baricity but there are very few clinical studies. In addition, although the majority of clinical studies have been conducted on local anaesthetics used for epidural anaesthesia, the number of clinical studies on intrathecal application of local anaesthetic for spinal anaesthesia is insufficient.

In a clinical study which compared spinal block made with 0.5% bupivacaine stored at 4˚C or 37˚C, the patients administered with 0.5% bupivacaine stored at 37˚C were positioned supine after 3 minutes in a sitting position and it was determined that cephalic dissemination seen in the spinal anaesthesia was greater and more rapid compared to that of the patients administered with 0.5% bupivacaine stored at 4˚C. The reason for this was stated to be that an increase in the temperature of the local anaesthetic was effective in the thermal equalisation with cerebrospinal fluid in a shorter time [13]. In a clinical study of 76 elective caesarean cases, following spinal anaesthesia made with 4˚C heavy bupivacaine and 23˚C heavy bupivacaine, the spinal block characteristics, and frequency and severity of the shivering were examined and although no differences were observed in respect of the block characteristics, an increase was determined in the incidence and severity of shivering in the patients inthe 4˚C heavy bupivacaine group [8].

In another clinical study of 36 patients using 37˚C and 25˚C heavy bupivacaine, in the comparison of the solution densities before application of spinal anaesthesia, although the measured values were similar, the baricity of the 37˚C heavy bupivacaine was found to be lower than that of the 25˚C bupivacaine. In the comparison of the block characteristics, the dermatome level where maximum sensory block was observed was higher but no difference was seen between the groups in respect of the time taken to reach maximum sensory block. It was reported that the reason for this could have been the difference in viscosity [5].

In another clinical study of 60 transurethral prostate resection

cases comparing 37˚C levobupivacaine with 25˚C levobupivacaine used for spinal anaesthesia, it was reported that the time taken by the sensory block to reach the T10 dermatome was shorter in the 37˚C group. It was concluded that there was a more rapid onset of sensory block with the use of 0.5% levobupivacaine at 37˚C, but in that study there were no data related to the effect on shivering of the use of 0. 5% levobupivacaine at 37˚C [14].

Sensory block was reported to be achieved in a shorter time with no side effects from the use of bupivacaine at 37˚C for epidural anaesthesia in a study of 60 patients undergoing surgery on the lower extremities [15].

In the current study, a comparison was made of the characteristics of spinal anaesthesia applied using bupivacaine at 37˚C and at room temperature, and a more rapid onset of sensory and motor block and a more rapid cephalic dissemination were determined in the group administered with bupivacaine at 37˚C. These findings can be considered to be related on a thermodynamic basis to the lower density values and acceleration of the molecules in the local anaesthetic solution.

Researchers have shown that apart from the hypothalamus and skin surface, deep abdominal tissues and the spinal cord are also responsible for active thermoregulation. The motor centre of shivering is located in the hypothalamus. Shivering is inhibited by heat-sensitive impulses found in the preoptic region of the hypothalamus, but when the cold impulses are greater, the motor centre for shivering located in the hypothalamus is activated to send bilateral impulses to the motor neurons on the anterior surface of the spinal cord [16].

An increase of up to 400% is observed in oxygen consumption in the whole body associated with shivering, carbon dioxide production increases due to lactic acidosis and with an increase in catecholamine expression, there is an increase in the effort burden of the left ventricle [17]. Arterial O2 saturation falls due to shivering and intra-ocular and intracranial pressure increases. These events can increase morbidity and mortality because of complications in individuals with cardiopulmonary disease [18]. In addition, an increase in postoperative pain associated with wound site tension, and extended hospital stay with surgical bleeding, and the incidence of wound site infections may be observed with shivering [19].

Various studies have been conducted on the development of hypothermia and the incidence of shivering following central block. In a clinical study of 30 patients with a planned postpartum tube ligation operation, a 47% increase in the incidence of shivering was observed following epidural application of bupivacaine stored at 4˚C for epidural anaesthesia, then after injection of bupivacaine at 41˚C, the shivering observed in 8 patients was observed to be halted in 4 patients and the authors reported that the thermosensitive tissues of the spinal cord could contribute to the shivering seen following central block [20].

In a clinical study made to investigate hypothermia and shivering in caesarean operations applied under spinal and epidural anaesthesia, according to measurements taken from the tympanic membrane, the decrease in temperature in the spinal anaesthesia group was determined to be more rapid,but no difference was determined in respect of shivering [21].

In another study conducted to investigate the effect on shivering of a change in local anaesthetic temperature during epidural anaesthesia, a total of 40 patients were separated into 2 groups, one administered with bupivacaine at 37˚C and the other with bupivacaine at 4˚C. The incidence of shivering was found to be 27.5% in the whole patient group with shivering observed in 2 patients in the 37˚C bupivacaine group and in 9 patients in the 4˚C bupivacaine group [22]. In conformity with literature, the incidence of shivering in the 37˚C bupivacaine group of the current study was determined to be low. The thermosensitive tissues in the spinal cord can be considered to contribute to the low incidence.

In a study using bupivacaine at 4˚C in the application of spinal anaesthesia, an increase was determined in systolic and diastolic blood pressure values and increased vasoconstriction was held reponsible for the shivering observed in patients [8]. In another clinical study using levobupivacaine at 37˚C applied as spinal anaesthesia to patients, no difference was observed between groups in the incidence of hypotension and bradycardia [14]. In the current study, hypotension and bradycardia were observed less in Group 1 patients; the rate of shivering was high and it is thought that this resulted in an increased catecholamine level and increased left ventricle function. In addition, the development of hypotension and bradycardia seen at a high level in Group 2 can be considered due to the compensatory mechanisms associated with rapid cepahalic dissemination entering a relatively slower phase.

Conclusion

In caesarean operations applied with spinal anaesthesia, increasing the temperature of LA agent to 37˚C with the aim of providing a more rapid onset of sensory and motor block can be considered a good alternative. In addition, increasing the temperature of LA agent could reduce shivering in patients, but as there could be an increase in the development of hypotension and bradycardia, great care must be taken against these two complications.

Competing interests

The authors declare that they have no competing interests.

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